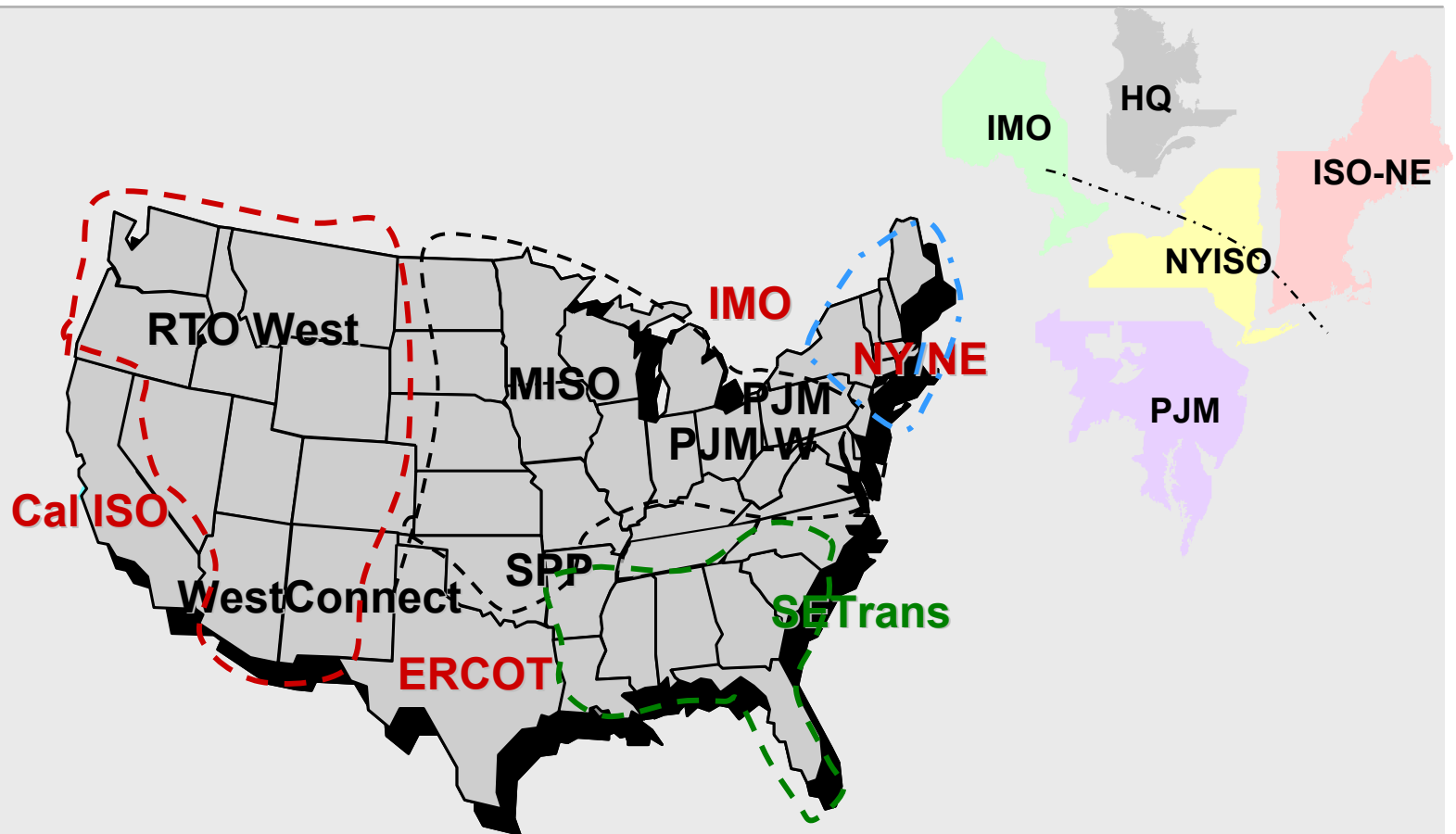


Markets for Transmission Rights

Harry Singh
PG&E Corporation

July 15, 2003
Toronto, Canada

Expanding/Shrinking RTOs



FTR/TCC/TCR auctions have been conducted in CA, NY, PJM, ERCOT and IMO

Transmission Pricing: The Past

- Physical rights awarded on a first-come, first served basis
- Network Service or Point to point Service
- Firm or Non-firm
- Bundles embedded cost recovery with congestion
- Average losses
- Pancaked rates
- Little price risk, high quantity risk

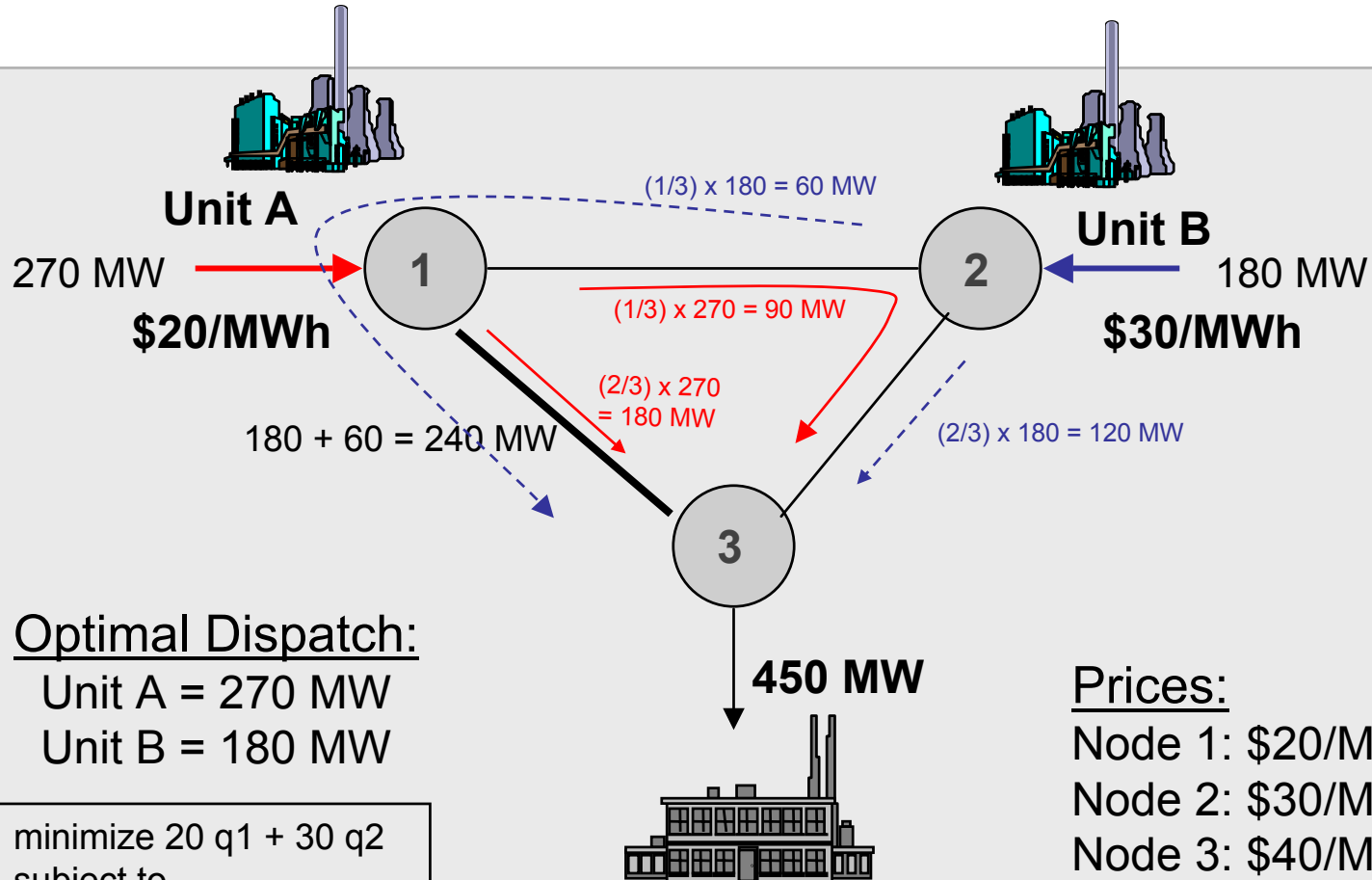
	Firm \$/kw-mo	Non-firm (\$/MWh) Peak	Off-Peak	Loss Factor %
AEP (East)	1.42	4.09	1.95	3.30
AEP (West)	1.05	3.02	1.44	2.90
Duke Energy	1.03	3.00	1.40	3.00
Southern	1.37	2.82	1.88	3.00
TVA	1.81	3.90	1.90	-
Virginia Power	1.07	3.08	1.46	2.34
Entergy	1.05	3.03	1.44	3.00

Transmission Pricing Tomorrow

- Access Charges without pancaking (embedded cost recovery)
- Congestion charges based on LMP differences
- Marginal Losses based on LMP differences

- Reduced quantity risk, high price risk
- Financial rights required for hedging

LMP Example with loop-flow



Optimal Dispatch:

Unit A = 270 MW
Unit B = 180 MW

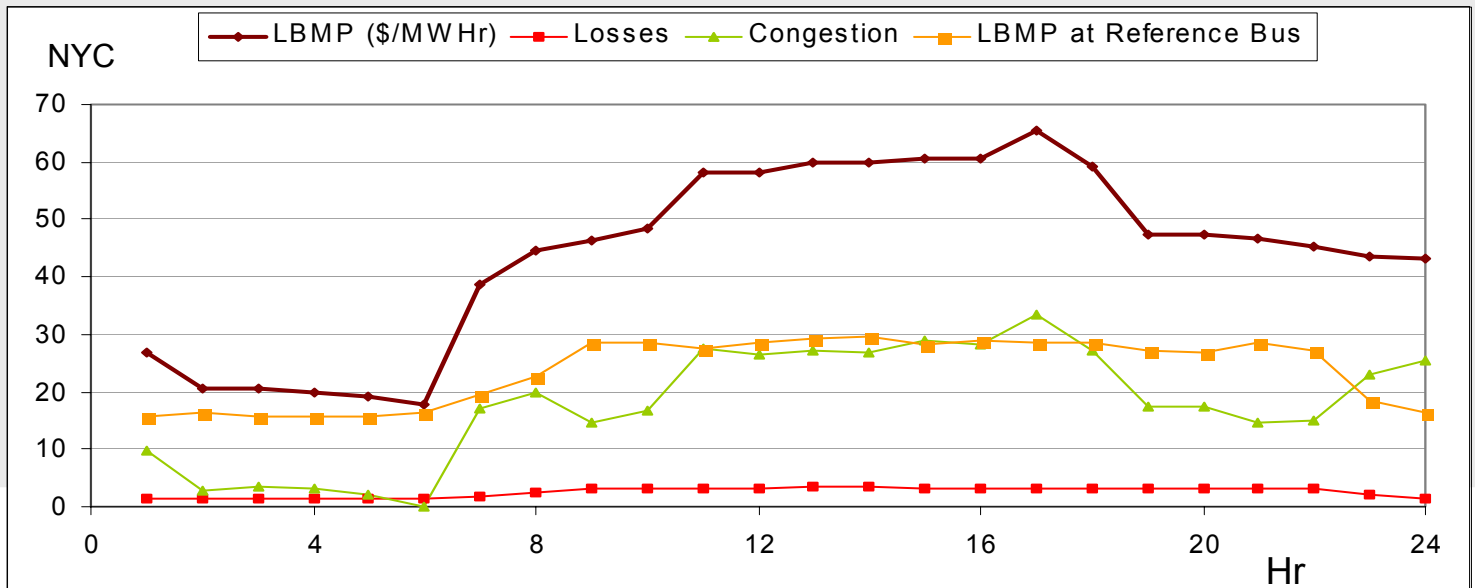
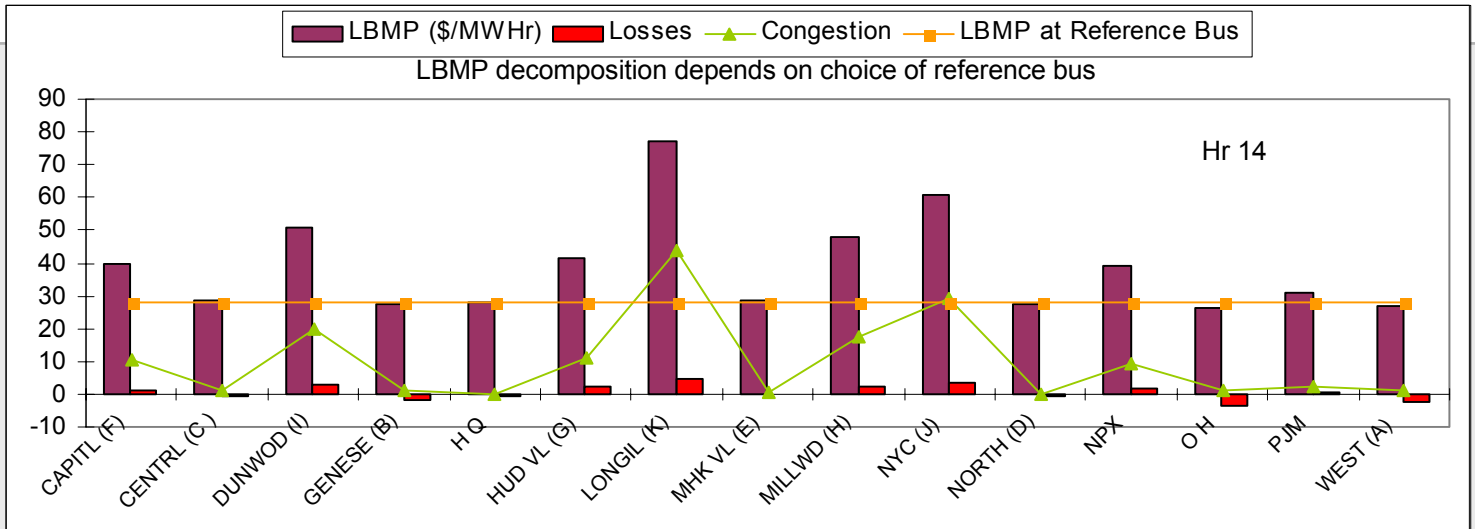
minimize $20 q_1 + 30 q_2$
subject to
 $q_1 + q_2 = 450$,
 $(2/3) q_1 + (1/3) q_2 \leq 240$,
 $q_1 \leq 400$, $q_2 \leq 400$.

Prices:

Node 1: \$20/MWh
Node 2: \$30/MWh
Node 3: \$40/MWh

All lines have equal impedance

LMP components (NYISO LBMPs June 5, 2002)



LMP components

- Energy
- Congestion
- Losses

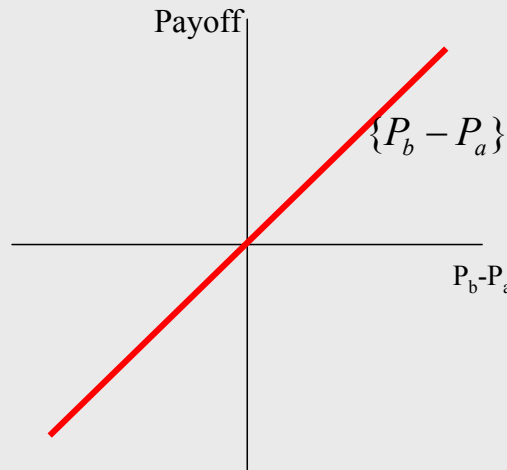
Options vs. Obligations

FTR Options

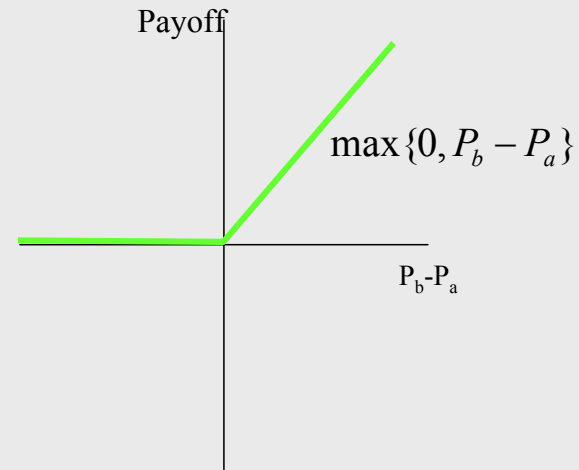
the right to receive payment without the requirement to pay

FTR Obligations

the right to receive payment coupled with the requirement to pay



Obligations



Options

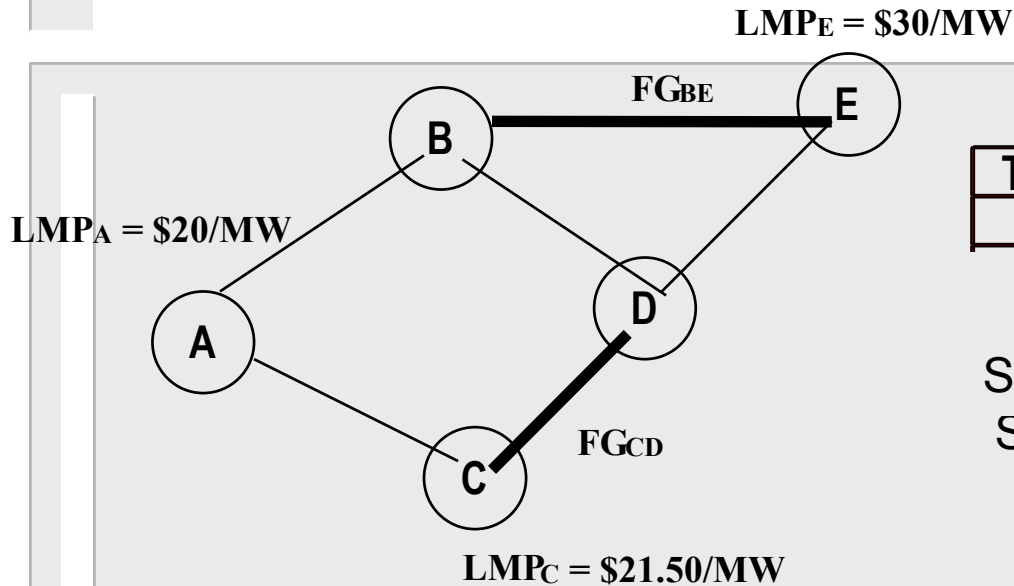
$$(p_b - p_a) = (p_{hub} - p_a) + (p_b - p_{hub})$$

$$(p_b - p_a) = -(p_a - p_b)$$

$$\max(0, p_b - p_a) \neq \max(0, p_{hub} - p_a) + \max(0, p_b - p_{hub})$$

$$\max(0, p_b - p_a) \neq -\max(0, p_a - p_b)$$

Flow-gate Example



PTDFs

Transactions	FG_{BE}	FG_{CD}
A to E	0.6	0.2

Shadow Price of $FG_{BE} = \$ 15.00$

Shadow Price of $FG_{CD} = \$ 5.00$

100 MW transaction from A to E would pay:

$(60) * (\text{Shadow Price of } FG_{BE}) + (20) * (\text{Shadow Price of } FG_{CD}) = \1000

Can be hedged by buying 60 MW FGRs on BE and 20 MW of FGRs on CD

Issues:

What happens if A-B becomes congested?

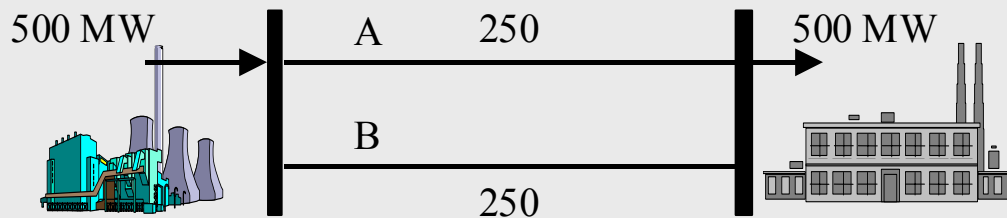
What if PTDFs change?

Number of nodes = N

Number of pt-to-pt rights = $2N(N-1)$, $N > 2$

Number of Flowgate rights = ?

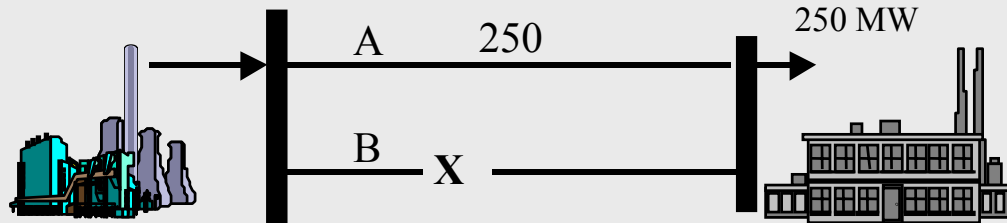
Contingencies, PTDFs and OTDFs



$$\begin{aligned} \text{PTDF (A)} &= 0.5 \\ \text{PTDF (B)} &= 0.5 \end{aligned}$$

Both Lines Operating: Transfer 500 MW

Contingency: One Line Might Go Out
Limit Transfer to 250 MW

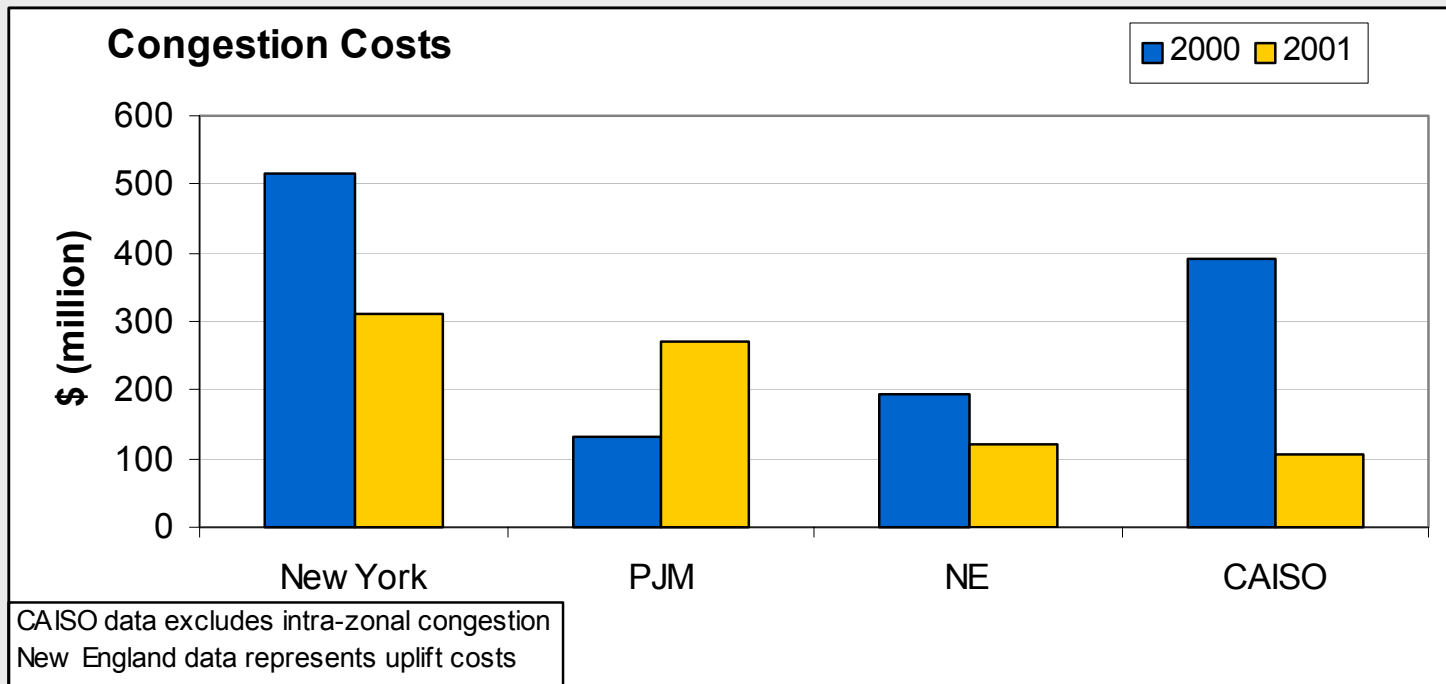


$$\begin{aligned} \text{PTDF (A)} &= 1 \\ \text{PTDF (B)} &= 0 \end{aligned}$$

Single Flowgate with an OTDF = 1

- PTDFs change with network topology
- Security constraints can be represented implicitly

RTO Congestion Costs



Note: Different congestion management approaches were in effect in different markets in 2000-01. NY and PJM used a nodal LMP Approach, CA used a zonal approach and NE had a regional uplift approach. NE introduced nodal LMP in March 2003.

Design Choices for Transmission Rights

Nature of Rights

- Physical or Financial
- Options or Obligations
- Point to point (PTP) or Flow-gate rights (FGRs)
- Decomposition of PTP rights using hubs
- Fully funded or subject to outage/derate risks

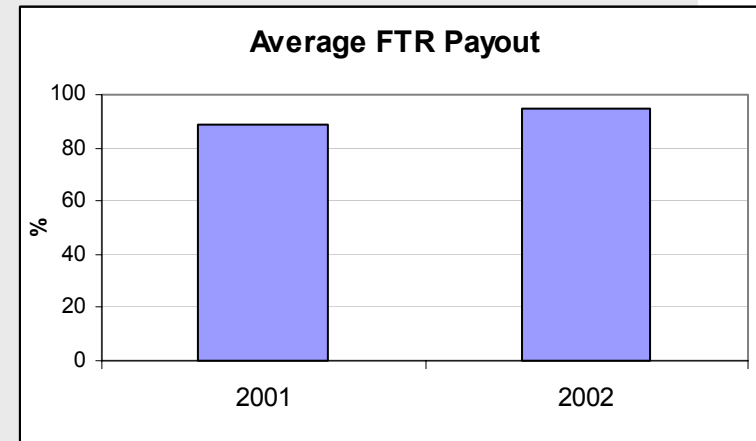
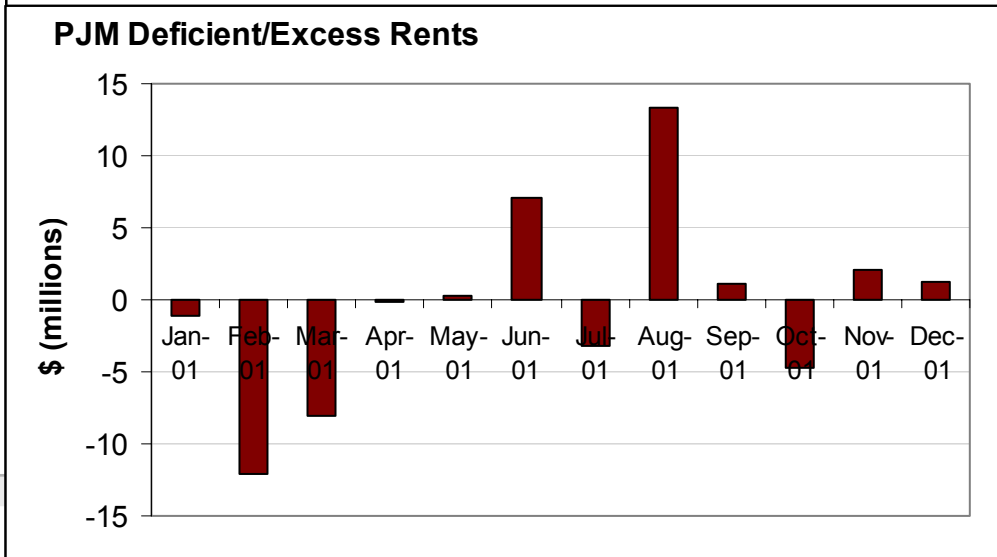
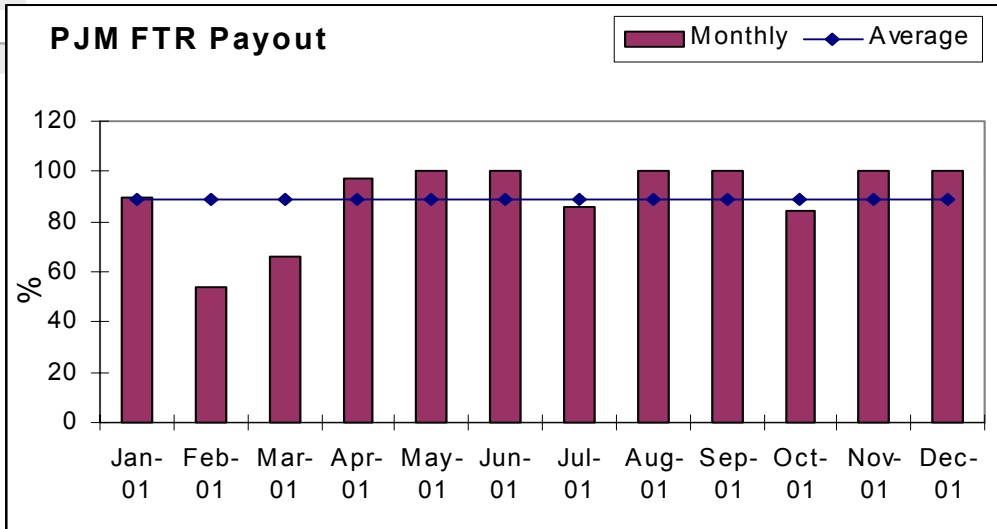
Other Issues

- Auctions or Allocations
 - Treatment of Auction Revenues
 - Customer Switching
 - Existing Contracts
- “Revenue adequacy” requires any set of awarded rights to be “simultaneously feasible”

FERC SMD and Transmission Rights

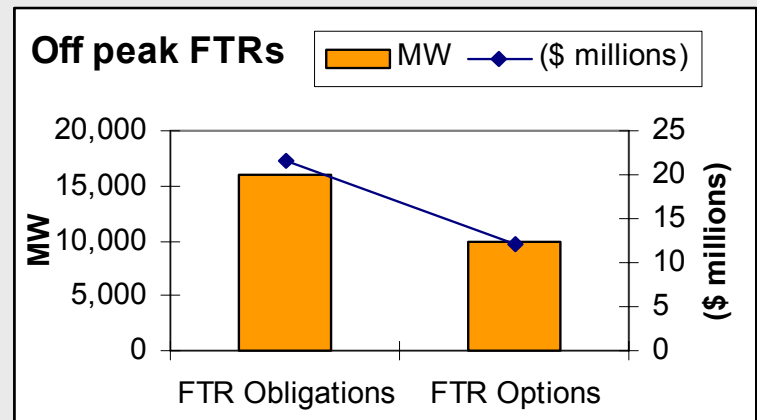
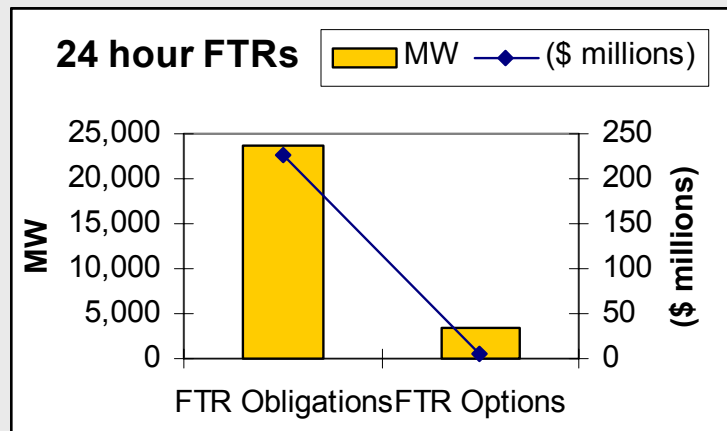
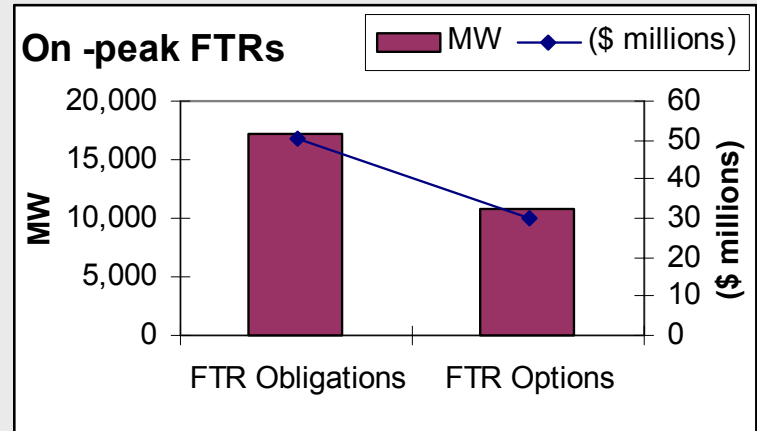
- Transmission provider must offer source-to-sink obligations
- “Upon the request of market participants, the transmission provider must also offer source-to-sink *options* and *flowgate rights* as soon as it is technically feasible”
- Auctions are unlikely to be required at least initially

Revenue Adequacy



2003 PJM Auction: PTP Options and Obligations

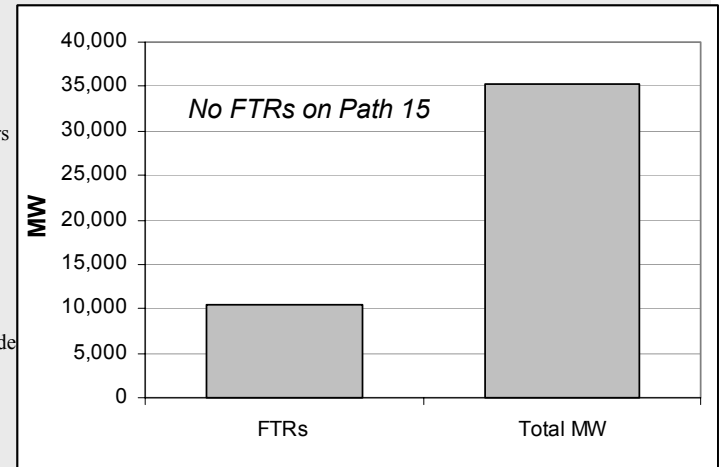
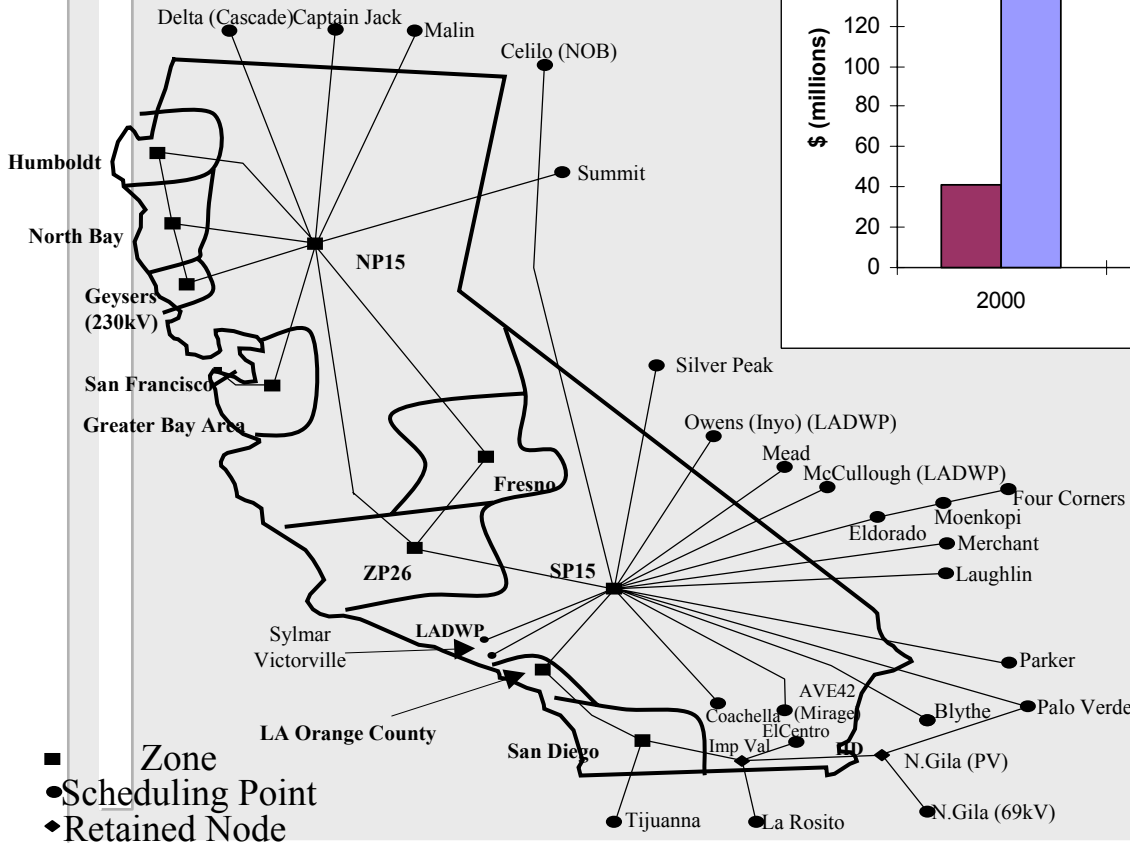
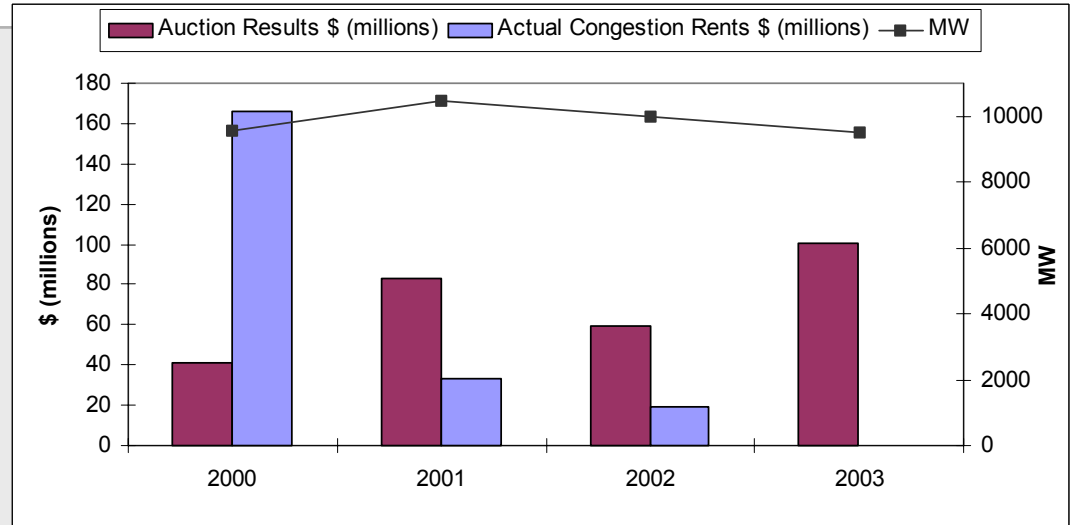
- 4 round auction offered both PTP Options and Obligations
- Approximately 50 participants
- Over 600,000 submitted bids



Source: PJM

CA FTR Auctions

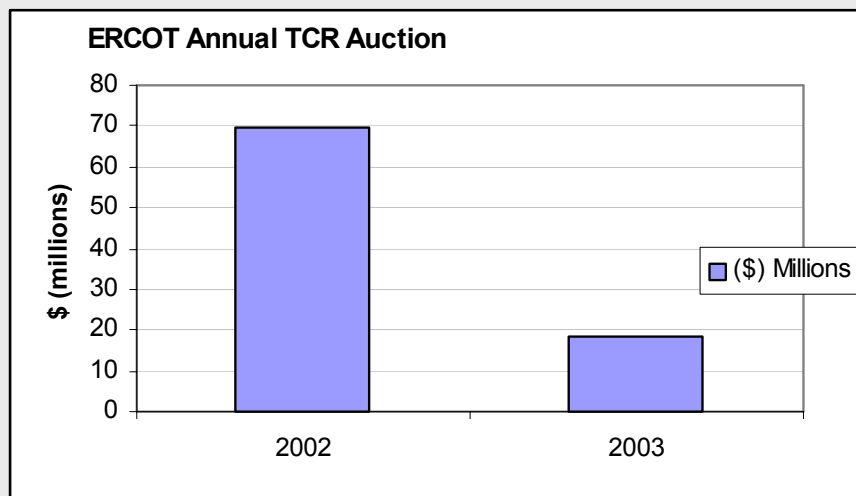
- Past auctions offered zone-zone options
- Future auctions to offer PTP obligations



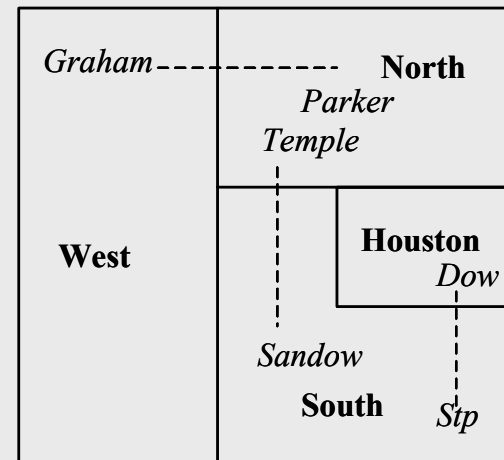
Source: CAISO

ERCOT TCR Auctions

- TCRs offered as inter-zonal options



ERCOT



TCR Shift Factors

$$p = H' \mu$$

p = LMPs
 μ = Shadow prices
 H' = Shift factor matrix

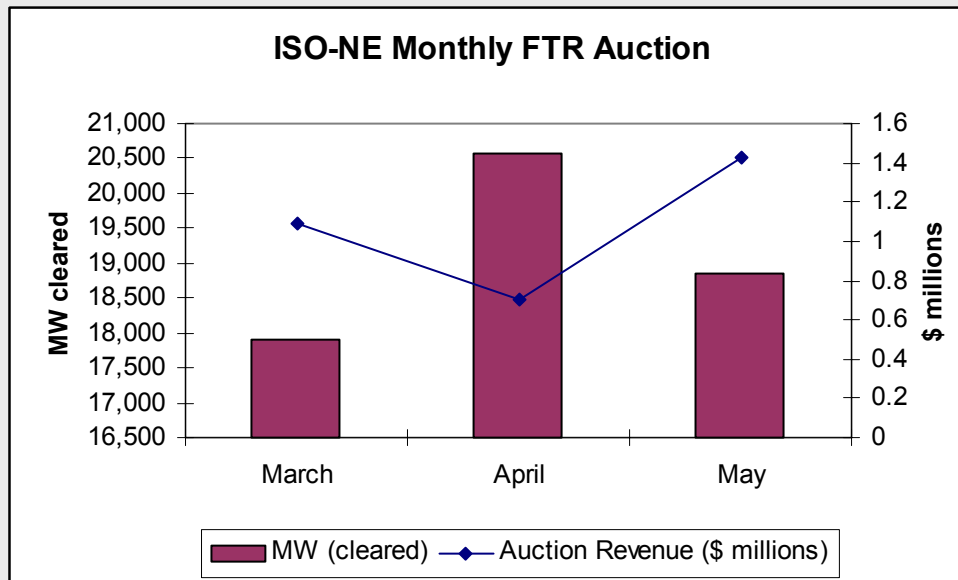
$$H' =$$

	W-N	S-N	S-H
CM	Graham to Parker	Sandow to Temple	Stp to Dow
Zone	G to P	S to T	Stp to D
Houston	0.027650492	0.204409959	-0.169735742
North	0.004613148	0.004989182	-0.003475207
South	0.04591408	0.396734818	0.190336475
West	0.580664652	0.032884411	0.016168457

Source: ERCOT

New England

- Monthly auctions initiated in March 2003
- Annual auction to be introduced in the future
- PTP obligations
- On-peak and off-peak FTRs



Transmission Rights in different RTOs

	Physical or Financial	Type of FTR
PJM	Financial	PTP obligations and PTP options
NY	Financial	PTP obligations
NE	Financial	PTP obligations
CAISO	Financial with scheduling priority	zonal FGRs (old), PTP obligations (future)
MISO	Financial	PTP obligations and options, FGRs
ERCOT	Financial	zonal FGRs
SETrans	Financial	PTP obligations (day 2)
West Connect	Physical	FGRs